

AVERAGE VELOCITY

VELOCITY (\vec{v}) is a vector that describes how quickly an object's position changes, as well as the direction of this change.

SPEED (v) is a scalar that measures the magnitude of velocity.

Both speed and velocity are measured in meters per second (m/s).

Objects travelling at the same speed can have different velocities. Imagine two escalators travelling at the same speed, one going up, and the other going down. Because they are travelling in opposite directions, one of the directions has a negative sign. Thus, they have different velocities.

Velocity can be determined from the slope of a position-time graph. Where the graph shows a straight line, the velocity is constant. The slope is calculated as follows:

$$\begin{aligned}\text{Slope} &= \frac{\text{rise}}{\text{run}} \\ &= \frac{\Delta \vec{d}}{\Delta t} \quad \begin{array}{l} (\Delta \vec{d} = \vec{d}_f - \vec{d}_i) \\ (\Delta t = t_f - t_i) \end{array}\end{aligned}$$

The slope shows, on average, how far an object has moved in a certain time interval. In other words, the slope shows the object's average velocity.

AVERAGE VELOCITY (\vec{v}_{av}) is the rate of change in position over a time interval. It is almost impossible for an object to move at a perfectly uniform rate. Many factors, such as wind or an uneven surface, may cause the object to slightly speed up or slow down. Average velocity “smoothes out” these changes. It is a vector and includes direction. The slope of a position-time graph can be positive, zero, or negative.

If moving away from the origin is considered positive:

- a positive slope represents the average velocity of the object moving away from the origin
- a horizontal line, which has a zero slope, represents an object at rest
- a negative slope represents the average velocity of the object moving back toward the origin.

Since **AVERAGE VELOCITY** is the slope of a position-time graph, it can be written as follows:

$$\vec{v}_{av} = \frac{\vec{\Delta d}}{\Delta t}$$

By using this relationship, you can calculate the average velocity without analyzing a position-time graph.

For example: A sprinter takes 8.2s to run forward 75.0m. What is the sprinter's average velocity?

$$\begin{aligned}\vec{\Delta d} &= 75.0\text{m} \\ \Delta t &= 8.2\text{s}\end{aligned}$$

$$\begin{aligned}\vec{v}_{av} &= \frac{\vec{\Delta d}}{\Delta t} \\ &= \frac{+ 75.0\text{m}}{8.2\text{s}} \\ &= + 9.1\text{m/s}\end{aligned}$$

Thus, the sprinter ran 9.1 m/s forward.

This equation can also be rearranged to calculate displacement or time.

For **DISPLACEMENT**:

$$\vec{\Delta d} = (\vec{v}_{av})(\Delta t)$$

For **TIME**:

$$\Delta t = \frac{\vec{\Delta d}}{\vec{v}_{av}}$$

CONVERSIONS FOR CALCULATING AVERAGE VELOCITY

Sometimes it will be necessary to change from one unit of measurement into another. For example, the SI unit of measurement for both speed and velocity is metres per second (m/s). In daily life, kilometres per hour (km/h) is a common unit when representing both speed and velocity.

To convert a velocity given in km/h to m/s, you must first change kilometres to metres, then hours to seconds. Given that 1000m = 1km and 3600s = 1h, multiply by an appropriate distance conversion factor and then by a time conversion factor. For example, 55km/h [W] becomes

$$\frac{55 \text{ km}}{1 \text{ h}} \times \frac{(1000 \text{ m})}{(1 \text{ km})} \times \frac{(1 \text{ h})}{(3600 \text{ s})} = 15 \text{ m/s [W]}$$

Common Units

$$1 \text{ km} = 1000 \text{ m}$$

$$100 \text{ cm} = 1 \text{ m}$$

$$1 \text{ h} = 3600 \text{ s}$$

$$1 \text{ min} = 60 \text{ s}$$

REMEMBER:

AVERAGE VELOCITY

$$\vec{v}_{\text{av}} = \frac{\Delta \vec{d}}{\Delta t}$$

DISPLACEMENT

$$\Delta \vec{d} = (\vec{v}_{\text{av}})(\Delta t)$$

TIME

$$\Delta t = \frac{\Delta \vec{d}}{\vec{v}_{\text{av}}}$$